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XVIII.—NOTES ON THE GENERAL GLACIATION OF THE ROCKS IN THE NEIGHBOURHOOD OF DUBLIN. By the Rev. MAXWELL H. CLOSE.

[Read before the Royal Geological Society of Ireland, May 11, 1864.]

(Plate V.)

IT has long been known that the phenomena of rounding, smoothing, and scoring of rock surfaces, now almost universally attributed to the action of ice in some shape or other, are well exhibited in different localities round Dublin. In the "Journal" of our Society, and in the Explanations of Sheets 102 and 112 of the Geological Survey Maps, striations and other marks of abrasion are recorded as occurring on the rocks in several places along the Drogheda Railway, on Lambay Island, at Howth, at Killiney, and on Bray Head.* Many of the particulars about to be described have been, I know, observed by different persons; but I am not aware that any tolerably *connected* account of them has been given. Some such connected and sufficiently detailed account is, from the nature of the case, often necessary to secure the correct interpretation of the phenomenon in hand at particular places.

This paper treats especially of the *general* Glaciation of the neighbourhood. The subject presents in this district two points of particular interest. The general glacial stream has here invaded what was doubtless the domain of the local ice-system of the Dublin and Wicklow mountains; and the relations of the two might be here ascertained, if we had sufficient evidence to go upon; and, moreover, it is interesting to observe, as the evidence fully enables us to observe, how the current, after passing across a considerable extent of plain country, has been affected by the obstruction of the mountains.

It seems best to state at once, though reasons cannot now be given without anticipating, that this paper has been written under the conviction that that current consisted of *glacier* ice, which probably covered the greater part of the country, and hereabouts came from the W. N. W.

The small accompanying map, Plate ~~I~~, will give a tolerable general idea of the phenomena in question, but it may be well to point out more in detail the places where those phenomena present themselves. In giving the directions (true, not magnetic) of the striations, &c., it will be sufficient to set down the points *from* which they run. V

In the railway cutting at Donabate, at a short distance from the station, on both sides of the railway, but especially on the western, where is the fairest example, scorings occur on the greenstone, direction

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* It is necessary to note an evident typographical error in our "Journal," vol. iii., p. 61. Professor Oldham is there made to say, in an abstract of a paper by him, that he found rock scorings on Bray Head, N. 23° E., and S. 23° W. This has misled Mr. Jamieson ("Journal of the Geological Society," London, 1862) into supposing that that part of the country has been swept by ice from the bed of the Irish Channel. It is certainly true that at one place, under the lee side of the hill, the striations have curved round almost into that direction; but on comparing this with another paper, by Professor Oldham, vol. iii., p. 132, it will be seen that he must have written N. 23° W., and S. 23° E.; which is the direction of some good grinding to be seen on the upper part of Bray Head.

N. 57° W. In the churchyard of the Roman Catholic chapel at Donabate, on Old Red Sandstone conglomerate, the mean or normal direction is about N. 70° W. On the shore at Portrane, on Silurian slaty rock, the striations are to be seen peeping out from under the bank of drift: owing to the inequalities of the surface, they vary a little on each side of the mean direction, N. 66° W.; at one spot they run nearly at right angles to this, affording, apparently, one of the very few examples of cross striations. In the large quarry, one-fifth of a mile S. S. E. of the town of Malahide, on Carboniferous Limestone, the direction is N. 82° W.; and in two small quarries, three-fourths of a mile S. E. of the town, on the same rock, the normal direction is the same. On the island of Ireland's Eye the masses of vein-quartz occurring in the Cambrian quartz rock are, in many places, well polished and striated; direction N. 63° W. On the Hill of Howth, not merely the vein-quartz, but the Cambrian quartz rock itself and the grits and slates have well retained, in many places, the marks of grinding, in the rounding, smoothing, and scoring of the surface. Striations are to be seen at one-fourth of a mile east of St. Fintan's Church; at a short distance south of the summit of Kilmartin Hill, at an elevation of 500 feet; on the top of Carrickbrack Hill, a very good example; near Drumleck Point, elevation about 40 feet; a little to the north, and also to the south of Kitestown; at one-fourth of a mile S.W. of Casana Rock, where the striations (to be referred to again) run *down hill;* near the Nose of Howth; and, as I am informed by Mr. Westropp, on the shore near Sutton Station, the rock in this case being Carboniferous Limestone. The striations are remarkably parallel over the whole of the peninsula, whether on the level ground, at the top, or on the sides; the normal direction for the hill being just about N. 60° W. In a large quarry half a mile north of Raheny, and in a small quarry seven-eighths of a mile north of the same place, the limestone is scored in the direction N. 48° W. In a quarry three-eighths of a mile due north of Finglas Bridge, the same rock has striations whose normal direction is N. 64° W.

In all the cases now mentioned the striations have a very striking nearness of direction; their variations are entirely due to immediately local inequalities of surface. Turn we now to the south of Dublin, where we shall find great changes of direction connected with the larger physical features of the district. At one-eighth of a mile S. E. of Crumlin House the rock is limestone, striations N. 82° W. At three-eighths of a mile N. by E. of the cross-roads at Roundtown the same rock has scorings N. 74° W. At Dundrum, just to the south of the church, the granite is well rounded and scored, N. 60° W. In different places near Murphystown, granite, N. 54° W. At Stillorgan reservoir, and in different places about Foxrock, granite, N. 43° W. The normal direction of the striations on the three Killiney Hills (granite and mica slate) seems to be precisely the same as the last. A most striking example of grinding occurs just outside the N.W. corner of Killiney Park on the southern slope of Rochestown Hill. Besides scorings covering many square yards of mica slate and granite, there is a straight groove or moulding, nearly two yards long, nine inches wide, and 2½ inches deep. This and the parallel scorings run obliquely across the edges of the highly inclined beds of mica slate. Some small masses of quartz, having better resisted the abrasion, stand up a little from the surface, and have given rise to some miniature specimens of "crag and tail," which show not merely the line of the grinding, but the direction of the motion in that line. On the same hill are many striking *roches moutonnées*, but of these we shall speak again. Marks of grinding occur likewise on the middle, or Killiney Hill proper. On the N.E. shoulder of Dalkey Hill the striations can be seen near a wall opposite Ardsunnas Cottage, on the granite; also in a small quarry one-fourth of a mile N. E. of the summit of the hill, running straight up the hill; to be referred to again. At a short distance N. and N. E. and S. of Ballycorus chimney shaft the normal direction of the scorings, on mica slate and vein-quartz in granite, is due north, elevation 760 feet. In three or four different places in the wood on the east side of the Scalp the direction, on granite vein-quartz, is the same. Obscure but indubitable traces of grinding can be seen on the upper parts of the sides of the Scalp itself, showing that the current has flowed through that gorge. On the summit (912 feet) and sides of the knob which forms the top of Carriggologan Hill, or Shankill, on Cambrian quartz rock, especially on the quartz veins, the smoothing and striation still survive; the normal direction for that eminence being N. 8° E. Near the old church of Rathmichael the direction, on eurite and mica slate, is N. 46° W., evidently on account of the position of that place on the hip of Shankill.

The glaciation of Bray Head presents a peculiarly interesting and somewhat complete study in itself, to which we must return again; we shall now only note that the striations may be seen in a great number of places all about the hill, sometimes on the Cambrian grits and slates, but for the most part on the quartz rock and quartz veins; in different places along the sea side, both below and above the railway (see especially the northern end of the southernmost tunnel); near the small ruined church overlooking the southern end of Bray strand; on the top of the eminence, 653 feet; on the top of that close by to the south, marked on the 6-inch maps, 668 feet, where is some splendid grinding; in several other places along that quartz rock ridge; *in the depression* to the eastward of Ballynamuddagh farm-house; and in several places along the crest of the quartz rock ridge which rises to 793 feet, the highest point (itself scored) of Bray Head. The normal direction of the striations for the hill is N. 31° W., as appears on comparing those cases where there is least deflection arising from local conditions. On the little hill near Windgate, 532 feet, the scoring on quartz rock has the same direction almost exactly; as also in Kilruddery Deer Park, on the east flank of the Little Sugar-loaf. A careful adept will, I believe, be able to recognise on the greatly weather-shattered quartz rock on the very summit of that hill (1120 feet) some remains of the old glaciated surface which have escaped destruction. I believe even that the striation can be seen at one spot, its direction being N. 13° W. On the north-west side of the Little Sugar-loaf, three-eighths of a mile south-east of Hollybrook House, there is some well-ground quartz rock, the direction of the scoring being N. 24° E., evidently on account of the position of the spot, the current there having been shouldered off by the hill. On some quartz rock, three-eighths of a mile west by north of Kilmacanoge, the striations are N. 25° E.; the stream swept in a curve round the north-west base of the Little Sugar-loaf, into the valley of Kilmacanoge. In that valley we find, on the slope of the Great Sugar-loaf, and about west of its summit, striations running in the direction of the valley, and therefore nearly parallel to those near Kilruddery and on Bray Head. In the same part of the valley, and in the bottom of it, is a considerable extent of well-smoothed quartz rock, the striations on which have been almost, but not quite, obliterated by the weather. The ridge or hill on the north side of the Rocky Valley presents striations on the vein-quartz on its summit, 802 feet, and in different places for the distance of a mile, their general direction being about N. 44° E. The stream was here deflected by the mass of the Great Sugar-loaf; it must have flowed round the north-west flank of that hill, and on over the *col* or saddle (about 900 feet high), near Ballyremon Commons and the "Long Hill." At Greystones, along the west side of the railway, and north of the station, and also on the shore, at the north end of the village, there is some splendid scoring on Cambrian slates and grits, the normal direction for that place being N. 3° W. We find here an example of a second set of striations crossing the normal ones on the same surface, on fine clay slate, both being inclined to the edges of the cleavage. An adept will detect still surviving striations parallel to the normal ones at Greystones, on the quartz veins near the summit of the hill, 725 feet, 1½ mile due west of that village. Passing on southwards, we find that remarkable boss of quartz rock at Kilcool village, presenting striations whose normal direction is N. 6° E. Proceeding thence along the road due south, we find, at the distance of 1¼ mile on the left hand, and 1½ mile on the right hand, near Leabeg, on quartz-rock and quartz veins, striations whose normal direction has reached N. 18° E.

We shall now proceed no farther in this direction, and that for three reasons:—We have already transgressed our limits, and gone beyond "the neighbourhood of Dublin;" moreover, there is little friendly quartz rock remaining, to which we might look with some degree of confidence for recorded marks of grinding;* and lastly, and above all, what does remain seems to warn us, if we read its record aright—which is rather doubtful, however—that a step farther may entangle us with the *local* glaciation of the Wicklow mountains. (*See Appendix, at end.*)

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* When looking for glacial striation on the quartz rocks and their vein-quartz, it is necessary to guard against being deceived by the (structural) slickensides which occur so frequently among those rocks; but no person whose attention had been once drawn to the matter, could with ordinary care, mistake the one for the other. There are several cases on Bray Head and Shankill of glacially striated slickensides, the two sets of striæ crossing each other, and perfectly distinguishable.

We turn, then, for a moment to the country about fourteen miles west of Dublin. At 2¼ miles south-west of Maynooth, in the ditch on the right side of the road, there are to be seen scorings on the limestone, their direction being N. 22° E. In a quarry on the west side of the hill, marked on the Ordnance Maps 312 feet, 2½ miles nearly due south of Maynooth, the limestone has striations N. 19° E. These two examples are 1½ miles apart. In the quarries, half a mile south-west of Clane, scorings can be found in several different places. They vary in direction a good deal, owing to the very uneven surface of the rock; but the normal direction for that place is clearly just about N. 46° E. On Oughterard Hill, near Lyons, at a short distance N. N. E. of the Round Tower, and also three-quarters of a mile north-east of it, the slaty Silurian rock has striations N. 44° E. At the last-mentioned spot there are cross striations north, though not on the same surface with the others. *These* are rather indistinct, and the real nature of them is doubtful. The instances now mentioned in this neighbourhood form an equilateral triangle, whose sides are about 5½ miles in length.

We must now notice some parallel furrowing of a different kind. On reference to the shaded Sheets of the inch Ordnance Maps, containing the environs of Dublin, it will be seen that the country just now referred to between Maynooth, Clane, and Oughterard, has a number of ridges crossing it parallel to each other, and to the rock striations nearest to them. Some of these ridges, *e. g.* the hill above mentioned, 312 feet, 2½ miles south of Maynooth, are chiefly, as it seems, composed of solid rock, and shaped up by drift. Some, *e. g.* the hill at Ardrass, 1¼ miles north-east of Straffan, whose summit is marked on the Ordnance Map 308 feet, are entirely composed of drift. The ridge now mentioned is a very well defined and noticeable one, perfectly parallel with the others, blunt at its up-stream end, and tailing off gradually in the opposite direction, distinct as to its composition and structure from an esker, yet somewhat similar in form. It is described by Mr. Du Noyer as "an esker-*like* mound."

Proceeding northwards from Maynooth, we find all the country from about Dunshaughlin to the sea at Portrane and Malahide, and over a width of several miles, in parallel ridges and troughs. In some parts this conformation is very striking; it is apparent even on the unshaded maps, from the number of streams, roads, and fences whose directions have been determined by the shapes of the ground. These ridges are parallel to the rock scorings at Portrane, Donabate, Malahide, Finglas, and Howth, and nearly at right angles to those south of Maynooth and their associated scorings. (*See accompanying map*, Plate I.)

No one can doubt, then, that these ridges and troughs and the rock striations are effects of one and the same cause, since they always correspond with each other as to direction, whatever that direction may be. Now, it has never been shown that moving water can score rocks in parallel lines by sweeping detritus along over them; neither sea waves, nor rivers, nor violent torrents (as Mr. Jamieson has shown in the case of the bursting of the Crinan Canal reservoirs) are able to effect this. Water currents, then, have not produced the rock scorings, and therefore they have not produced the ridges and troughs. That agency has indeed been at work, and, apparently at the expense of the parallel ridges, which have been sometimes partially, sometimes entirely obliterated thereby, has formed some esker mounds in the district, and, a little south-east of Trim, an esker ridge, five miles long, of most distinctive character, and inclined to the others at an angle of about 20°.

Since the parallel ridges and the rock striations have been produced by the same agent, which must have been the glacial stream, we may avail ourselves of the evidence afforded by them jointly in investigating the course of that stream.

Let us look for a moment beyond our limits, and note that the north-westerly and south-easterly ridging may be traced backwards, most distinctly, from Dublin and Meath into south Cavan, Westmeath, Longford, and south Leitrim at least. It largely affects the outlines of several of the lakes in the district now mentioned. The strike of the ridging makes a continuous curve towards the north as we follow it backwards into Leitrim, so that there its direction is north by west and south by east. Mr. F. J. Foot, of the Geological Survey, has kindly informed me that this parallel conformation of the country is very remarkable near Longford, and that the rock-scorings to be seen four miles east of that town correspond in direction with the ridges and troughs.

We have then evidence of the continuous course of that part of the glacial stream with which we are concerned, by which we see that, having flowed from beyond Longford, across the intervening plain country towards Dublin, it became divided by the resistance of the mountains, the place of division being well defined, and situated about four miles north-east of Maynooth (*see map*); one part turned sharply to the right, and flowed towards the S. S.W. by Clane; the other continued its course straight onwards for a little, and swept round the northern end of the Dublin and Wicklow range of mountains, turning gradually southwards into the wake of the mountains, and running along, for some distance at least, under their lee, nearly parallel to the present coast line. But while sweeping round, it also swept, partly at least, over the end of the range and among the outlying hills thereof. It has left its traces in *roches moutonnées* and ground vein-quartz, at the height of just about 1000 feet on the north side of the Three-Rock Mountain; its marks show that it flowed over the top of Shankill, and over and through the Scalp, into the wide valley of Enniskerry and Powerscourt, over Bray Head, and, as I now firmly believe, over the top of the Little Sugar-loaf (1120 feet). We needed not its traces in the valleys of Kilruddery and Kilmacanoge to assure us that it has swept through those passes. The striations near the Rocky Valley show that it must have passed between the Great Sugar-loaf and Douce into the valley of the Vartry River.

As the glacial stream passed along, it did much more than merely score the rocks; it ground them down into *roches moutonnées*, which in some places are very striking and characteristic. See, for instance, those on the up-stream side (the north-west) of Rochestown Hill, as also the rounded surface of the north-east shoulder of Dalkey Hill, opposite Ardsunnas Cottage. The rock there, granite, has stood well to be ground, instead of being ripped away in blocks; and the amount of pure abrasion that it has undergone to superinduce its present form of surface has evidently been enormous. The striations have been removed by weathering, except in a few places, where they are still perfectly distinct. Dalkey Island is well worth a visit, if only for the sake of its rounded rocks. The contrast between a down-stream view, in which only the rounded sides of the rock bosses are visible, and an up-stream view, in which their rough lee sides are visible, is exceedingly striking: the scoring has survived only in two places—near the battery, and near the martello tower, on a quartz vein. It is interesting to compare, on that island, the effects of glacial and of marine denudation which are presented in juxtaposition, and to note the difference.

The rounded aspect of the naked summit of Shankill, as seen especially from the west, is very remarkable; the flowing and swelling shapes of the whole of that hill have been evidently rasped out of granite, highly-inclined mica slate, and intractable quartz rock. The humps and prominences on Bray Head, composed of quartz rock, are very decidedly rounded, on the large scale, as well as on the small; this is very visible, to a slightly practised eye, from a distance of a couple of miles, especially if the light be favourable. This rounding, as before, is only on the up-stream side of the prominences. The rounding on a large scale was, doubtless, for the most part, chiefly effected by ripping the rock away in blocks; and it might, therefore, often be very observable, though the rock might have suffered comparatively little from pure grinding.

Some other apparent effects of the glacial stream remain to be noticed; but it will be best now to consider what evidence this district affords as to the nature of that stream. If, then, it were glacial, it must have consisted, not of floating, but of land ice. This conclusion seems *necessitated* (1) by the regular determined flow of the striations, whether regarded on a wide or on a closer view; (2) by the marks of *steady* up-hill grinding on Dalkey Hill and Bray Head,* for instance; though, of course, a floating mass impinging on a slope could force its foremost end a little way up that slope (3) by the marks of *down-hill* grinding on the lee side of Howth, as above mentioned; and on that of Killiney Hill, by Mount Eagle House; these, belonging unquestionably to the general glaciation, could not have been caused by any floating mass; (4) by the fact that striations are often to be found at a lower level than the up-stream ground in their vicinity; the scorings near Finglas Bridge, Raheny, and Portrane, and some on Bray Head, are thus situated. The case last mentioned seems to be worthy of special observation. That great band of quartz rock on Bray Head which forms a prominent ridge, one of whose summits is marked on the Ordnance Maps 653 feet, has on its lee-side a depression or slight valley running parallel to it across the main crest of Bray Head; in this depression is situated the farm-house of Ballynamuddagh, and about 256 yards to the E. N. E. of this house we find some smoothed and scored rock. The striations are parallel to the others about the hill, and belong indubitably to the general glaciation, and point directly towards the ridge above mentioned. It is manifest that the scoring agent has flowed over that ridge, and down into the depression on its lee-side, more than eighty feet below, within a distance of a quarter of a mile, which, of course, could not be done by ice floating in the ocean. An inspection of the place will show at once that, if floating ice has ever grated across the glaciated rock now spoken of, it must *necessarily* have moved in a direction nearly at right angles to that of the actual striations on that rock. We may observe that it seems very hard to believe that the naked summit of Shankill and the naked north-east shoulder of Dalkey Hill could have been ground into their present shapes by floating ice. All the striations *hitherto mentioned* are evidently related to one and the same cause; they have been produced by a continuous stream whose sinuosities are clearly explained by the shapes of the ground. If, then, any have been traced by land ice, all must have been so; and that ice has been, in the neighbourhood of Bray at least, over 1120 feet deep.

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* It is interesting to note that the scoring agent has moved straight up the north-west side of Dalkey Hill, the inclination of the ascent being 11½°. Bray Head affords a more striking case still. The striations at the up-stream end of that hill give satisfactory evidence that the scoring agent has moved from the sea level, at the southern end of Bray strand, directly up the side of the hill, to that summit, whose height is 653 feet, in the horizontal distance of exactly half a mile. The inclination of the slope, as a whole, is 14°; but near the top the scoring agent has moved almost straight up a tolerably plane slope, whose length is twenty-seven yards, and inclination 28°. The striations are to be seen on the quartz in several different places on that surface; it is perfectly certain that the movement was upwards, and not downwards. These facts may throw some light on the question, whether the ice of a large glacier could go down into a hollow in the glacier's bed, and up again out of it at the lower end.

There are reasons for suspecting that at some period it was much deeper, probably before the time when the stream flowed as its present traces indicate. Whatever may be the real significance thereof, there are well-scratched pebbles in the limestone drift beside Caldbeck Castle, on Kilmashogue Mountain, just above the 1250 feet contour line; and close by Fairy Castle, on the summit of the Two-Rock Mountain, at the height of fully 1760 feet, there are several stones along a boundary fence, some well-rounded and as large as a man's head, of far-transported material, viz., limestone and a white sandstone.

There are some facts which make it scarcely rash to conjecture that at one time the glacial stream may have moved right across the long ridge of the Dublin, Wicklow, and Wexford Mountains, viz., the remarkably rounded outlines of those mountains, even to the summit of Lugnaquilla itself, 3039 feet, notwithstanding the great hollows or "prisons" which have been scooped out of its sides; the parallelism of the transverse valleys to each other, and to the direction of the undisturbed current north of Dublin; the straightness and better definition of those valleys on the east side of the mountain range; the fact that their *cols* are often situated to the west of what seems to have been the original position of the watersheds of the passes: the last two peculiarities are precisely what might have been superinduced by a glacial flood of sufficient denuding efficacy, coming from the north-west, *partly dammed-up* by the long mountain barrier, and pouring over the crest thereof down the steeper slope of its lee side. It seems not imprudent to suspect that such may possibly turn out to be the case, when we reflect that the striations across the summit of Shiehallien, in Scotland, 3533 feet above the sea, and across the top of Mansfield Mountain, Vermont, U. S., 4848 feet above the same level, have been attributed to the action of land ice by Agassiz and Professor Dana, respectively. If the glacial stream did ever flow across the Dublin, Wicklow, and Wexford Mountains, it was doubtless before the time when that barrier was able to split the stream at the distance of about eleven miles, near Maynooth.

There are some features, besides those already noticed, which seem to be the result of glacial denudation. The country between Dundrum and Dalkey, and Kingstown and Carrickmines, has some wide ridges and troughs running parallel to the rock scorings, *e. g*, the ridge along whose crest Rochestown Avenue, near Killiney, runs; that of Glenageary, that of Galloping Green and Foxrock, &c. It is clear, from the striations upon the Killiney Hills, and also from the general facts, as shown on the map about that part, that the glacial movement has not been there determined in direction by those ridges and troughs, but that, if there is any relation, they are dependent upon it.

That remarkable gap, the Scalp, cuts across a ridge which is transverse to the direction of the glacial movement. It is almost exactly parallel to the scorings mentioned above, to the east of it. The ice has flowed, as its traces show, through that pass; it would there act, owing to the shape of the ground, with concentrated force. It is the property of actions, like the glacial, working in one direction, that if, owing to some cause or other, they have succeeded in working a slight hollow or channel in a particular place, they will tend to work with increased efficiency in that channel when produced: this fact constantly presents itself to our notice, and the reason of it is obvious. It accounts for the deep grooves and flutings that are sometimes ground (not ploughed) out on well glaciated rocks. The Scalp may be compared to what we may sometimes see, a single groove of this sort; but yet it is not all alone, for 1½ mile to the north of it we have a miniature copy of it in the Dingle (not in the same line), and one-third of a mile to the west of the latter, another little channel or valley, a shallow one; the two last mentioned cut across a low ridge. And again, one mile west of the Scalp, is what we may call the Gap of Ballybetagh, close to Ballybetagh House. These four gaps or channels are all parallel to each other, and, be it observed, their floors are at very different elevations, that of the Dingle being about 380 feet above the sea; that of the Scalp, 502 feet;

and that of Ballybetagh Gap, about 650 feet. It seems as if no explanation can be applied to the Scalp which does not include the cases of the other evidently related gaps. They can all be with equal ease accounted for by glacial action, and under this view their difference of elevation presents no difficulty whatever. The Glen of the Downs might be mentioned in this connexion, and perhaps even certain ravines beyond it, parallel to striations in their vicinity; but the farther we go in that direction the greater is the need of caution, and it will be safer to stop.

We must not omit to notice what some will regard (but, it is respectfully submitted, without sufficient reason) as a disproof of the denuding power of the ice. It has evidently sometimes flowed, as certain modern glaciers do, over the detrital matter beneath it. This is shown by the often magnificent grinding occurring on the upper surfaces of *large* boulders buried in the drift; this grinding is in one direction, and parallel to that on the rock *in situ;* this might have been seen at the Stillorgan and Vartry valley reservoirs, and may yet be seen in an old gravel pit in Foxrock. But if the ice at one time and place flowed over such blocks and their enveloping detritus without disturbing them, it had previously, when perhaps more actively working, brought them thither from elsewhere, so that its power of denudation remains unassailable.

With reference to the transportation of blocks, Mr. Jukes informs us ("Manual," p. 678), that "the Leinster granite sends off boulders in all directions, except the north, but chiefly towards the south-east." Surely this is because the local ice system of the mountains was, to a great extent, interfered with and overborne by the general glacial movement from the north-westward.

APPENDIX.

Although the striation on the summits of Dunran Hill, 1122 (*see map*, D), and Carrick Hill, 1252 feet (C), may not belong to our subject, it is well to mention it. The normal direction of the striations for both hills shows that the grinding has been *from* west by north, *i. e.*, from the mountains. This is quite clear on Dunran Hill, and still more so on Carrick, where the quartz rock ridges have been rounded on one side, precisely like those on Bray Head. The striations on the south-westerly side of Dunran Hill run obliquely *down-hill;* they therefore cannot have been produced by floating ice. Moreover, floating ice could not have ground those summits in the direction of the striations. Did it float across the mountain range, or through the lowest available gap? It must have passed some hundreds of feet above the tops of the two hills. Did it float from the mountains themselves, on a current flowing *steadily* away at right angles to the partly submerged but continuous ridge? This would be, apparently, impossible. The striations were evidently not effected by the proper ice covering of those two hills, as they have no relation to the slopes. Nothing remains but th[illegible] were produced either by the general glacier crossing the mounta[illegible] range, or by the ice of the local glacial system of the mountains. If the latter alternative be selected, that local system must have been of enormous development; those hills being of the heights mentioned, and both situated at least ten miles from the mountain crest, whose mean elevation is not more than 2100 feet, though it rises much higher in different places.